Atomic Physics

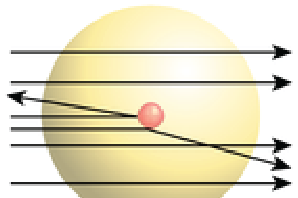
PHYSICS WALLAH

RUTHERFORD'S ATOM MODEL

i) Majority of α - particles passed without any deviation.

ii) Some are scattered at small angle θ (impact parameter is equal to that of nuclear radius)

iii) Only few alpha particle retrace the path (impact parameter = 0)

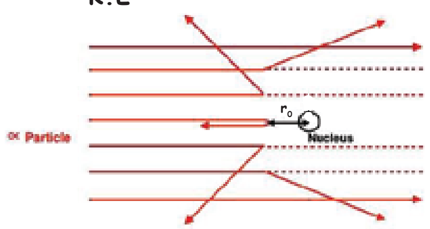


DISTANCE OF CLOSEST APPROACH OF α-PARTICLES

$$r_0 = \frac{1}{4\pi\varepsilon_0}\frac{4Ze^2}{mv^2}$$

$r_0 \propto \frac{1}{m}$ $\quad r_0 \propto \frac{1}{v^2}$

$r_0 \propto \frac{1}{K.E}$ $\quad r_0 \propto Z_1Z_2$

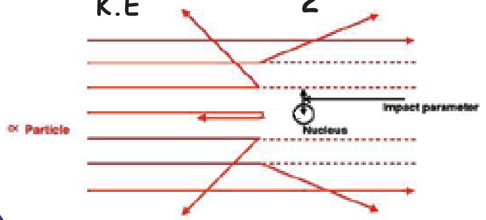


IMPACT PARAMETER

$$b = \frac{1}{4\pi\varepsilon_0}\frac{Ze^2\cot\frac{\theta}{2}}{\frac{1}{2}mv^2}$$

$b \propto \frac{1}{m}$ $\quad b \propto \frac{1}{v^2}$

$b \propto \frac{1}{K.E}$ $\quad b \propto \cot\frac{\theta}{2}$



BOHR ATOM MODEL

First postulate

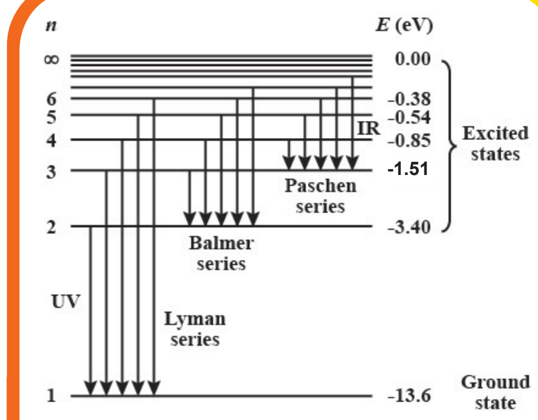
$$F = \frac{1}{4\pi\varepsilon_0}\frac{Ze \times e}{r^2}$$

Second postulate

$$mvr = \frac{nh}{2\pi}$$

$$\frac{mv^2}{r} = \frac{1}{4\pi\varepsilon_0}\frac{Ze^2}{r^2}$$

- RADIUS OF ORBIT $\quad r_n = 0.53\frac{n^2}{Z}$
- VELOCITY OF ELECTRON $\quad v_n \propto \frac{Z}{n}$
- TIME PERIOD $\quad T \propto \frac{n^3}{z^2}$
- FREQUENCY $\quad = \frac{1}{T} \propto \frac{z^2}{n^3}$
- CURRENT $\quad = \frac{e}{T} \propto \frac{z^2}{n^3}$
- MAGNETIC FIELD $\quad B \propto \frac{v}{r^2} \Rightarrow B \propto \frac{z^3}{n^5}$
- MAGNETIC DIPOLE MOMENT $\quad M \propto n$



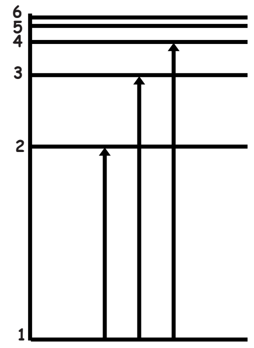
As the n value increases, the energy difference betwen adjacent level decreases

$5\rightarrow1 > 4\rightarrow1 > 3\rightarrow1 > 2\rightarrow1 > > 4\rightarrow2 > 3\rightarrow2$

$E_{max} \propto \lambda_{min} \propto V_{max}$

HYDROGEN SPECTRUM

Absorption spectrum



Electrons absorb only those photons whose energy =Energy difference of 2 shells

If atomic excitation takes place upto n^{th} shell starting from ground state then (n-1)different photons are absorbed

ENERGY

Total energy $= -13.6\frac{z^2}{n^2}$ eV

K.E = -T.E = $+13.6\frac{z^2}{n^2}$ eV

P.E = 2T.E

λ_{max}

E_{min} (first line)

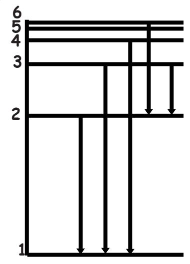
$$\lambda_{max} = \frac{n^2(n+1)^2}{(2n+1)R}$$

λ_{min}

E_{max} (Last line/ Series Limit)

$$\lambda_{min} = \frac{n^2}{R}$$

EMISSION SPECTRUM



Total no. of different wavelength photons in emission spectrum $= \frac{n(n-1)}{2}$

All absorbed photons are emitted in emission spectrum

Wavelength of emitted photon

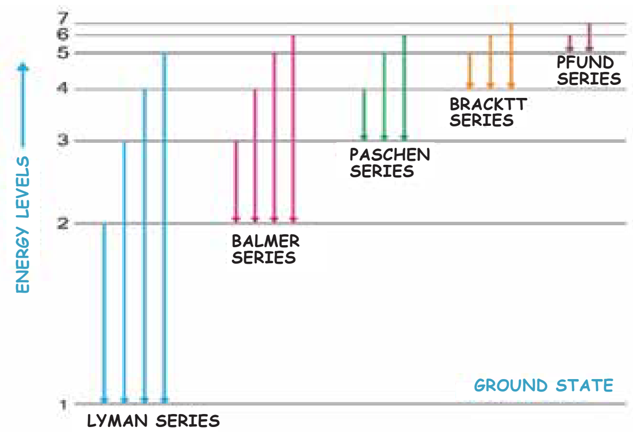
$$\overline{V} = \frac{1}{\lambda} = R Z^2\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$$

$$\frac{1}{R} = 91nm = 910\mathring{A}$$

$R \approx 10^5\ cm^{-1}$

$R \approx 10^7\ m^{-1}$

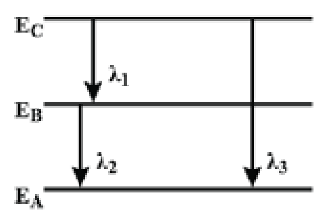
LINE SPECTRUM OF HYDROGEN ATOM



LINE SPECTRUM OF HYDROGEN ATOM

Spectral series	n_1	n_2	Wavelength	λ_{max} $(n_2=n_1+1)$	λ_{min} $(n_2=\infty)$	$\frac{\lambda_{max}}{\lambda_{min}}$	Region	Range
Lyman	1	2,3,4	$\frac{1}{\lambda_{Ly}} = R\left(\frac{1}{1^2} - \frac{1}{n^2}\right)$	$\frac{4}{3R}$	$\frac{1}{R}$	$\frac{4}{3}$	Ultra - violet	911.6 Å to 1216 Å
Balmer	2	3,4,5	$\frac{1}{\lambda_B} = R\left(\frac{1}{2^2} - \frac{1}{n^2}\right)$	$\frac{36}{5R}$	$\frac{4}{R}$	$\frac{9}{5}$	Visible	3646 Å to 6563 Å
Paschen	3	4,5,6	$\frac{1}{\lambda_P} = R\left(\frac{1}{3^2} - \frac{1}{n^2}\right)$	$\frac{144}{7R}$	$\frac{9}{R}$	$\frac{16}{7}$	Near infar-red	8204 Å to 18753 Å
Brackett	4	5,6,7	$\frac{1}{\lambda_{Br}} = R\left(\frac{1}{4^2} - \frac{1}{n^2}\right)$	$\frac{400}{9R}$	$\frac{16}{R}$	$\frac{25}{9}$	Middle infra-red	14585 Å to 40515 Å
Pfund	5	6,7,8	$\frac{1}{\lambda_{Pf}} = R\left(\frac{1}{5^2} - \frac{1}{n^2}\right)$	$\frac{900}{11R}$	$\frac{25}{R}$	$\frac{36}{11}$	Far infra-red	22790 Å to 74583 Å

Energy levels A,B & C of a certain atom correspond to increasing values of energy, i.e. $E_A < E_B < E_C$. If $\lambda_1, \lambda_2, \lambda_3$ are the wavelengths of radiations corresponding to transitions C to B, B to A and C to A respectively then



a) $\lambda_3 = \lambda_1 + \lambda_2$ $\quad$ c) $\lambda_1 + \lambda_2 + \lambda_3 = 0$

b) $\lambda_3 = \frac{\lambda_1\lambda_2}{\lambda_1 + \lambda_2}$ $\quad$ d) $\lambda_3^2 = \lambda_1^2 + \lambda_2^2$